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FACTORS RELATED TO FLAVOR STABILITY OF FOAM-DRIED MILK. II. EFFECT OF HEATING MILK PRIOR TO DRYING

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SUMMARY

The flavor of stored samples of vacuum foam-dried whole milk powders made from milk heated prior to drying was determined organoleptically. Heating milk at 165 F for 30 min, 170 F for 6 min, and 195 F for 15 sec effectively stabilized the flavor of air-packed samples during six months of storage at 80 F. These treatments had little or no effect on the flavor stability of samples packed in nitrogen containing either 1.0 or 0.1% oxygen. As oxidative deterioration during storage was checked by heat treatments in excess of pasteurization requirements, increased cooked flavor in and staling of the dried products was noted.

In our laboratory, it was found that extending the shelf life of foam-dried whole milk by gas packing required in-package oxygen levels below those obtainable with commercial gas-packaging equipment (10). Therefore, it became desirable to further study other means of stabilizing the flavor of this product.

Other authors' studies (1, 3, 5, 7) have shown that heating milk in excess of pasteurization requirements, prior to drying, conferred on spray-dried whole milk a stability against oxidative change.

This paper presents data pertaining to the flavor of stored samples of vacuum foam-dried powder made from milks subjected to a variety of heat treatments. The effect of these heat treatments on the flavor of gas-packed samples also is included.

Lack of suitable chemical and physical techniques (8) limited the evaluation of flavor quality of the samples to an organoleptic method.

METHODS AND MATERIALS

Pilot plant capacity restricted this study to four heating variables per lot of milk used. Possible variation in composition of milk during the course of the work was reduced by using mixed-herd milk from cows maintained on an invariant husbandry regime at the Agricultural Research Center located at Beltsville, Maryland.

Experimental samples of powder were produced by drying, under high vacuum, foamed concentrates made from heated milk (9). Variations in the heat treatment of the milk were carried out during the pasteurization step in all cases except one, where additional heating of the concentrate prior to drying was carried out.

Heating milk 6 min or longer was done in a steam-jacketed pan equipped with a stirrer, or in a 150-gal capacity Cherry-Burrell[1] spray pasteurizer. Plate heating and steam injection were carried out by using a custom-designed deodorizer-pasteurizer of 5,000-lb/hour capacity (4). A Mallory[1] tubular heater having a 100-gal/hour capacity was used for high temperature–short time work.

The powders containing 26% fat and approximately 2.5% moisture were packaged in hermetically sealed tin cans. Conditions were controlled in such fashion that representative samples of each type of powder were packaged in air, nitrogen containing 1.0% oxygen, and nitrogen containing 0.1% oxygen.

All powder samples were stored at 80 F and reconstituted for flavor evaluation at two-month intervals.

A ten-man taste panel evaluated the flavors of all stored samples, using the methods and score-card previously described (10). Data obtained in this fashion were analyzed statistically. Preliminary study showed such wide variance of judge response to strong off flavors

[1] The use of trade names is for the purpose of identification only, and does not imply endorsement of the product or its manufacturer by the U. S. Department of Agriculture.

TABLE 1

Interaction of in-pack oxygen level and heat treatment observed in series No. 26. Mean flavor scores (MFS) averaged over 2, 4, and 6 months of storage at 80 F

Heat treatment	In-pack O_2 level (%)	MFS	Rank
163 F 15 sec Plate	0.1	36.14	a
163 F 15 sec Steam injection flash deodorize to 140 F	0.1	35.94	ab
163 F 15 sec Steam injection flash deodorize to 150 F	0.1	35.94	ab
165 F 30 min Holder	0.1	35.67	ab
165 F 30 min Holder	1.0	35.44	ab
163 F 15 sec Plate	1.0	35.17	ab
165 F 30 min Holder	Air	34.73	b
163 F 15 sec Steam injection flash deodorize to 140 F	1.0	33.90	c
163 F 15 sec Steam injection flash deodorize to 150 F	1.0	33.70	c
163 F 15 sec Steam injection flash deodorize to 140 F	Air	32.21	d
163 F 15 sec Plate	Air	31.95	e
163 F 15 sec Steam injection flash deodorize to 150 F	Air	31.89	e

that all scores below 30 were automatically raised to this level to normalize the data for computation.

Each series of four experiments performed, using a single lot of milk, was analyzed as a separate entity, using the analysis of variance (2). Where significance was found in the analysis, a mean comparison was made, using Duncan's Multiple Range test. Using the standard error of the mean, and the degrees of freedom for error in the analysis of variance, the values obtained from a 5% Significant Studentized Ranges table were adjusted. The resulting values were the minimum differences between means which, if exceeded, indicated that the compared means were different.

RESULTS

The reproducibility of data of the type presented in this paper was determined by triplicating a study of the flavors of stored air- and gas-packed samples of vacuum foam-dried powders made from milks receiving heat treatments equal to and in excess of those required for pasteurization. Excellent agreement in the results of these studies was noted, with the mean separations verifying the previously reported effect of decreasing oxygen level in the packages on improved flavor stability (10). The expected improvement of flavor stability in powders made from milk heated in excess of pasteurization requirements was also noted. The analysis of variance indicated interaction between heat treatment and the oxygen level in the packages. Table 1 presents this interaction and the relative rank of the mean flavor scores (MFS) of the two-, four-, and six-month-old samples. All MFS having a similar letter in common in the ranking column are statistically indistinguishable. These data pertain to one of the replicate series. All others were similar.

Similar interactions between oxygen level in packages and heat treatment are shown in Tables 2, 3, and 4. Each table represents data obtained from powders made from a single lot of milk, divided and heat-treated, using a variety of conditions designed to determine the optimum heat treatment for maximum flavor stability of the product stored in air and gas packs.

The type of flavor in the samples, as detected by the judges, is partially reported. For simplicity's sake, the flavor in each sample considered most objectionable by the judges has been tabulated. The four most commonly occurring defects are considered individually; all

TABLE 2

Interaction of in-pack oxygen levels and heat treatment observed in series No. 19. Mean flavor scores (MFS) averaged over 2, 4, and 6 months of storage at 80 F

Heat treatment	In-pack O_2 level (%)	MFS	Rank
145 F 30 min Plus 165 F 30 min on conc.	0.1	35.38	a
145 F 30min	0.1	35.32	a
165 F 30 min	1.0	35.24	a
165 F 30 min	0.1	35.23	a
185 F 30 min	1.0	35.17	a
185 F 30 min	0.1	35.09	a
145 F 30 min Plus 165 F 30 min on conc.	1.0	34.56	a
165 F 30 min	Air	34.28	ab
145 F 30 min	1.0	33.15	bc
185 F 30 min	Air	33.09	bc
145 F 30 min Plus 165 F 30 min on conc.	Air	32.20	cd
145 F 30 min	Air	31.69	d

TABLE 3

Interaction of in-pack oxygen levels and heat treatment observed in series No. 44. Mean flavor scores (MFS) averaged over 2, 4, and 6 months of storage at 80 F

Heat treatment	In-pack O_2 level (%)	MFS	Rank
150 F 6 min	0.1	36.23	a
145 F 30 min	0.1	36.00	ab
190 F 6 min	0.1	35.60	abc
190 F 6 min	1.0	35.46	abc
170 F 6 min	1.0	35.45	abc
170 F 6 min	0.1	35.33	bc
190 F 6 min	Air	35.01	cd
170 F 6 min	Air	34.97	cd
150 F 6 min	1.0	34.45	de
145 F 30 min	1.0	33.71	e
145 F 30 min	Air	30.00	f
150 F 6 min	Air	30.00	f

others have been consolidated. The effect of the oxygen level in the packages on the type of flavors found in the various groups of samples is shown in Table 5. The effect of the individual heat treatments on the frequency of flavor occurrence in all stored packs during the entire period is shown in Table 6.

DISCUSSION

Consideration of the data in its entirety demonstrates that like the flavor of spray-dried whole milk, the flavor of foam-dried whole milk samples packed in air or commercial type gas packs can be stabilized against oxidative changes during storage by applying a variety of heat treatments in excess of conventional pasteurization. The flavor of the more stable products, a combination of definite cooked and slight stale, cannot be considered like that of fresh market milk. However, the optimum heat treatments did produce readily soluble products which can be considered palatable.

TABLE 4

Interaction of in-pack oxygen levels and heat treatment observed in series No. 50. Mean flavor scores (MFS) averaged over 2, 4, and 6 months of storage at 80 F

Heat treatment	In-pack O_2 level (%)	MFS	Rank
275 F 15 sec	1.0	36.01	a
165 F 30 min	0.1	35.79	ab
275 F 15 sec	0.1	35.48	ab
165 F 30 min	1.0	35.45	b
250 F 15 sec	1.0	35.44	b
225 F 15 sec	0.1	35.43	b
225 F 15 sec	1.0	35.40	b
165 F 30 min	Air	35.35	b
250 F 15 sec	0.1	35.25	b
250 F 15 sec	Air	34.62	c
225 F 15 sec	Air	34.54	c
275 F 15 sec	Air	33.92	d

While a relatively simple picture of change in flavor is presented by mean flavor score ranking, it must be realized that it is highly deceptive without a consideration of the types of flavor which, in a somewhat arbitrary fashion, dictate the magnitude of the given score. For instance, in the scoring system used in this study, a definite cooked flavor in milk produces a relatively higher score than a slight oxidized flavor. If both defects were equally weighted, the results of the investigation, as presented by mean flavor scores alone, would have been somewhat different. Therefore, the type of flavor detected in the samples by the judges must be considered in evaluating the data.

The consumers' acceptance of the flavors typical of foam-dried powder made from heated milk is undergoing study at present, along with the relationships between consumer acceptance and the weighting factors used in the development of the score-card used in this study.

CONCLUSIONS

The flavor stability of vacuum foam-dried whole milk packed in air can be improved by heating milk to 165 F for 30 min, 170 F for 6 min, or 195-225 F for 15 sec. Heating above these levels results in no real further improvement of product, since the high levels of cooked flavor become objectionable.

The stabilizing effect of heat treatment decreases with decreasing oxygen level in gas packs. Heating milk in excess of pasteurization requirements, prior to drying, actually had little or no effect on the stability of products packaged in nitrogen containing 0.1% oxygen.

As oxidative changes in the samples were checked, stale flavor became the predominant defect in stored samples.

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TABLE 5

Effect of in-pack O_2 level on frequency of dominant off-flavor in products of all series. All storage times and heat treatments averaged together for computation

Series no.	In-pack O_2 level (%)	Per cent total judgments per specific flavor				
		Astr.	Cooked	Oxidized	Stale	Others
19	0.1	8.3	19.2	43.3	11.7	17.5
19	1.0	5.0	12.5	56.7	12.5	13.3
19	Air	2.6	13.8	62.9	13.8	6.9
26	0.1	11.7	20.0	24.2	20.0	24.1
26	1.0	5.8	15.8	44.2	15.8	18.4
26	Air	1.7	10.8	70.0	11.7	5.8
44	0.1	7.5	35.0	5.0	34.2	18.3
44	1.0	5.8	28.3	26.7	31.7	7.5
44	Air	3.0	19.0	40.0	22.0	16.0
46	0.1	5.9	37.0	17.6	24.4	15.1
46	1.0	6.7	34.2	24.2	25.0	9.9
46	Air	1.8	23.6	28.2	30.9	15.5
50	0.1	4.2	33.3	5.0	43.3	14.2
50	1.0	10.0	30.0	7.5	40.8	11.7
50	Air	6.7	18.3	16.7	41.7	16.6

TABLE 6

Effect of heat treatment of milk on frequency of dominant off-flavor in products of all series. All storage times and oxygen levels averaged together for computation

Series no.	Heat treatment	Per cent total judgments per specific flavor				
		Astr.	Cooked	Oxid.	Stale	Others
19	145 F 30 min	4.5	4.5	68.5	12.4	10.1
19	145 F 30 min + 165 F 30 min on conc.	4.5	12.4	61.8	9.0	12.3
19	165 F 30 min	4.5	24.7	51.7	10.1	9.0
19	185 F 30 min	7.9	19.1	34.8	19.1	19.1
26	163 F 15 sec	5.6	11.1	50.0	12.2	21.1
26	163 F 15 sec SIFD[a] to 140 F	7.8	8.9	60.0	16.7	6.6
26	163 F 15 sec SIFD[a] to 150 F	6.7	4.4	51.1	16.7	21.1
26	165 F 30 min	5.6	37.8	23.3	17.8	15.5
44	145 F 30 min	2.5	8.8	48.8	30.0	9.9
44	150 F 6 min	7.5	12.5	40.0	31.2	8.8
44	170 F 6 min	4.4	38.9	4.4	34.4	17.9
44	190 F 6 min	7.8	47.8	3.3	23.3	17.8
46	165 F 15 sec	6.3	5.1	59.5	20.2	8.9
46	165 F 30 min	5.6	46.7	11.1	25.6	11.0
46	195 F 15 sec	5.6	34.4	16.7	30.0	13.3
46	225 F 15 sec	2.2	37.8	10.0	30.0	20.0
50	165 F 30 min	7.8	35.6	6.7	35.6	14.3
50	225 F 15 sec	7.8	30.0	5.6	42.2	14.4
50	250 F 15 sec	4.4	20.0	15.6	45.6	14.4
50	275 F 15 sec	7.8	23.3	11.1	44.4	13.4

[a] SIFD: Steam injection flash deodorized.

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